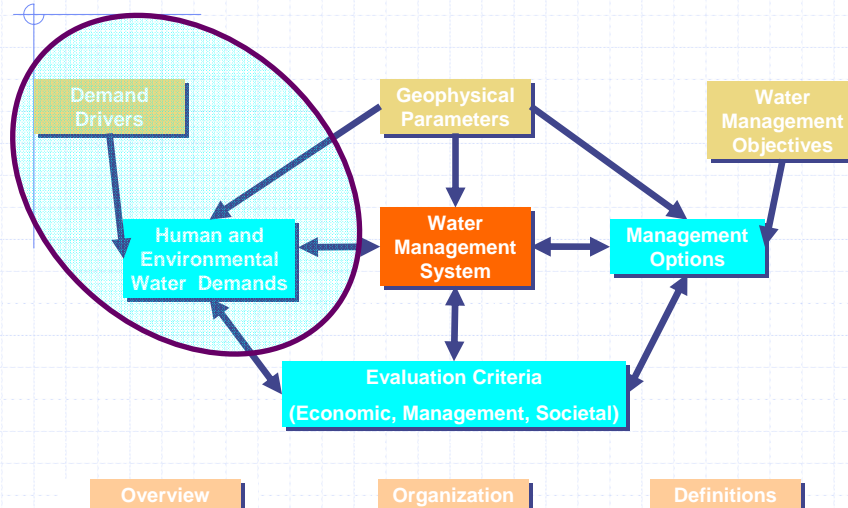


Agricultural and Urban Water Use Scenario Evaluation Tool

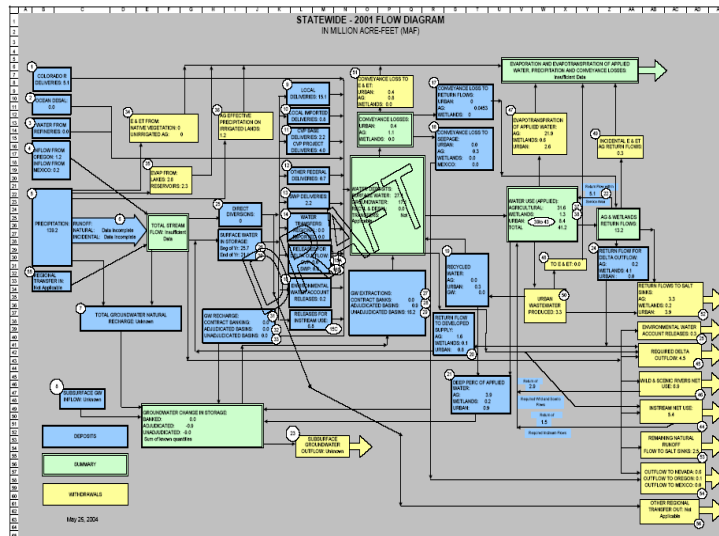
California Water Plan
Update 2004

1

Conceptual Framework

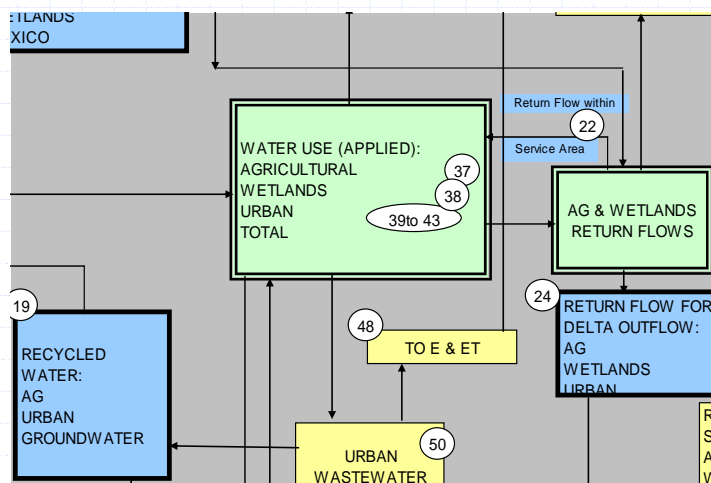


Flow Diagram



3

Flow Diagram - Water Use



4

Table 3-xx "Factors Affecting..."

FACTOR ¹	SCENARIO 1	SCENARIO 2	SCENARIO 3
	CURRENT TRENDS	RESOURCE SUSTAINABILITY	RESOURCE INTENSIVE
Total Population	DOF	DOF	Higher than DOF
Population Density	DOF	Higher than DOF	Lower than DOF
Population Distribution	DOF	DOF	Higher Inland & Southern; Lower Coastal & Northern
Commercial Activity	Current Trend	Increase in Trend	Increase in Trend (Same as Scenario 2)
Commercial Activity Mix	Current Trend	Decrease in High Water Using Activities	Increase in High Water Using Activities
Total Industrial Activity	Current Trend	Increase in Trend	Increase in Trend (Same as Scenario 2)
Industrial Activity Mix	Current Trend	Decrease in High Water Using Activities	Increase in High Water Using Industries
Total Crop Area (Includes Multiple Cropping)	Current Trend	Level Out at Current Crop Area	Level Out at Current Crop Area
Crop Unit Water Use	Current Trend	Decrease in Crop Unit Water Use	Increase in Crop Unit Water Use
Environmental Water-Flow Based	Current Trend	High Environmental Protection	High Environmental Protection
Environmental Water-Land Based	Current Trend	High Environmental Protection	High Environmental Protection
Naturally Occurring Conservation ²	NOC Trend in MOUs	Higher than NOC Trend in MOUs	Lower Than NOC Trend in MOUs

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Scenario factors that influence ag and urban water use

- ◆ Irrigated crop area
- ◆ Irrigated land area
- ◆ Crop unit water use
- ◆ Mix of annual and permanent crops
- ◆ Ag WUE
- ◆ Irrigated land retirement
- ◆ Total Population
- ◆ Population density
- ◆ Population distribution
- ◆ Commercial activity
- ◆ Industrial activity
- ◆ Urban WUE
- ◆ Naturally occurring conservation

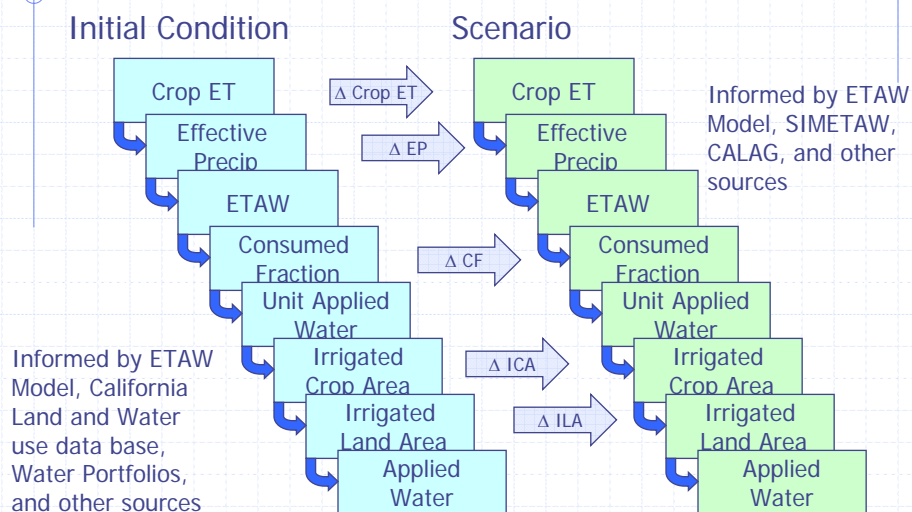
6

Ag and Urban Water Use Scenario Evaluation Tools

- ◆ Sensitivity analysis
- ◆ Quantification of uncertainty
- ◆ Informed by more-sophisticated models
- ◆ Interact with other tools as modules in an analytical environment
- ◆ Analytical environment accounts for the entire flow diagram

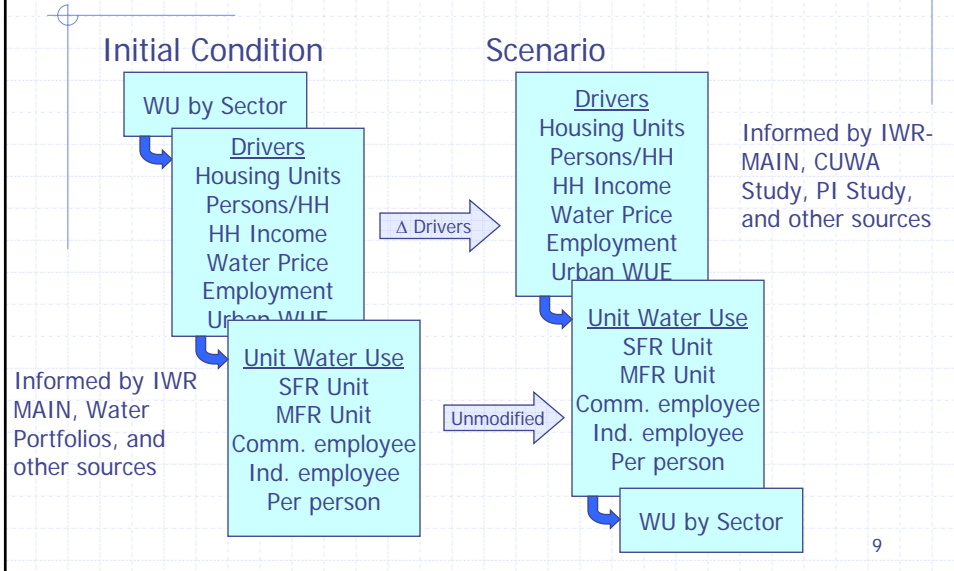
7

Ag Water Use



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Urban Water Use



Traditional Spreadsheet Approach

- ◆ Combination of single “point” estimates to predict a single result
- ◆ Can reveal sensitivity of dependent variables to change in model inputs
- ◆ Based on estimates of model variables
- ◆ Single estimate of results, i.e, cannot assess uncertainty inherent in model inputs

Simulation Approach

- ◆ Technical and scientific decisions all use estimates and assumptions
- ◆ The simulation approach explicitly includes the uncertainty in each estimate
- ◆ Results reflect uncertainty in input variables

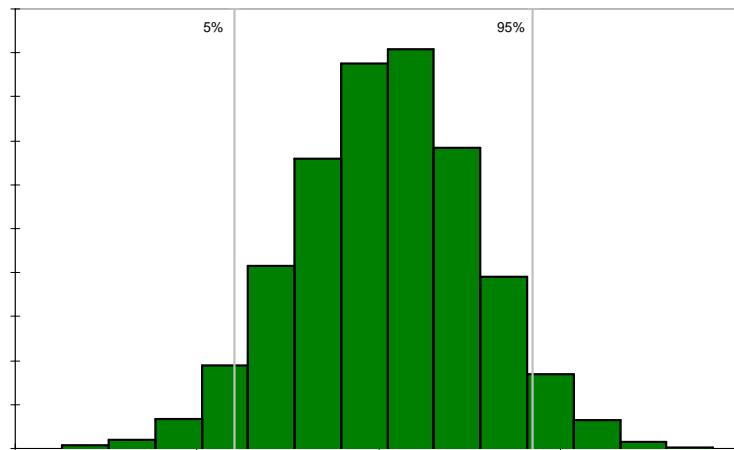
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Input Example: Crop ET probability distribution

Crop Group	Mean ET (AF/Ac)	Range (% +/-)	Std Dev	Distribution
Grain ET	1.6	5.0%	0.08	RiskNormal(B2, D2)
Rice ET	3.3	5.0%	0.16	RiskNormal(B3, D3)
Cotton ET	2.6	5.0%	0.13	RiskNormal(B4, D4)
SgrBeet ET	2.9	5.0%	0.14	RiskNormal(B5, D5)
Corn ET	2.2	5.0%	0.11	RiskNormal(B6, D6)
DryBean ET	1.8	5.0%	0.09	RiskNormal(B7, D7)
Safflwr ET	2.0	5.0%	0.10	RiskNormal(B8, D8)
Oth Fld ET	2.0	5.0%	0.10	RiskNormal(B9, D9)
Alfalfa ET	4.0	5.0%	0.20	RiskNormal(B10, D10)
Pasture ET	3.4	5.0%	0.17	RiskNormal(B11, D11)
Pr Tom ET	2.2	5.0%	0.11	RiskNormal(B12, D12)
Fr Tom ET	1.8	5.0%	0.09	RiskNormal(B13, D13)
Cucurb ET	1.7	5.0%	0.08	RiskNormal(B14, D14)
On Gar ET	2.4	5.0%	0.12	RiskNormal(B15, D15)
Potato ET	1.8	5.0%	0.09	RiskNormal(B16, D16)
Oth Trk ET	1.5	5.0%	0.08	RiskNormal(B17, D17)
Al Pist ET	3.2	5.0%	0.16	RiskNormal(B18, D18)
Oth Dec ET	3.2	5.0%	0.16	RiskNormal(B19, D19)
Subtrop ET	3.1	5.0%	0.15	RiskNormal(B20, D20)

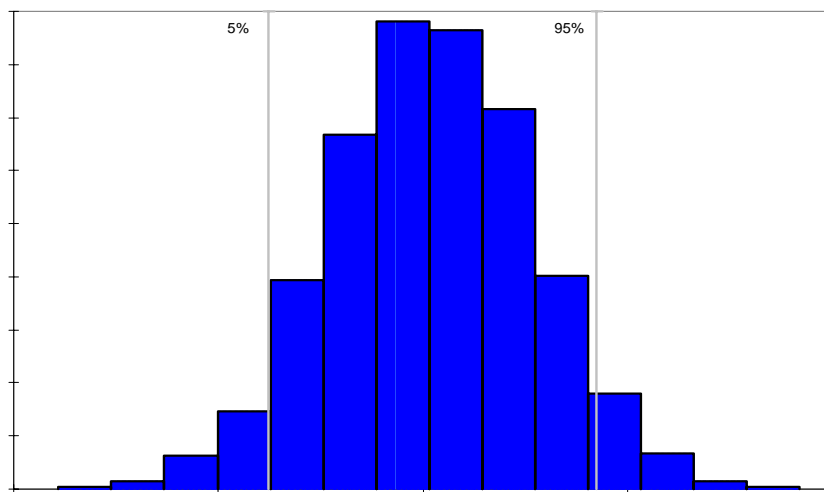
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Change in Agricultural AW 2000 to 2030



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Change in Urban AW 2000 to 2030



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Scenario Evaluation Tools in an Analytical Environment

- ◆ Multiple screening tools to serve various purposes
 - Ag water use
 - Urban water use
 - Water supplies
 - Water management options
- ◆ Each informed by more-sophisticated models
- ◆ Readily reveal sensitivity and uncertainty introduced through changes to model inputs.
- ◆ Housed as modules in a common analytical environment governed by a standard set of rules – Analytica, STELLA, Extend, Vensim

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Why Use an Analytic Environment?

- ◆ Communicate model structure
- ◆ Integrate documentation
- ◆ Ease of review and audits
- ◆ Collaboration
- ◆ Facilitate hierarchical structure
 - Manage complexity
 - Permit refinement and desegregation
- ◆ Exploration of uncertainty effects

Adapted from: Granger and Henrion. 1990. *Uncertainty, A Guide to Dealing with Uncertainty in Quantitative Risk and Policy Analysis*, Cambridge University Press.

The Analytica Modeling Environment

◆ Uses Influence Diagrams

■ Nodes

- ◆ Decision variables
- ◆ Chance variables
- ◆ Deterministic Variables

■ Arcs

- ◆ Indicates dependence or influence between nodes

◆ Uses a Hierarchical Structure

◆ More info at www.lumina.com

- Other environments similar

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Built in tools address uncertainty in several ways

◆ Probabilistically

- Assign probability functions to variables
- View results probabilistically

◆ Parametrically

- Explore the space of outcomes
- Pick individual parameters to define a scenario

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Easy, built in displays and user interface facilitate understanding

- ◆ Quick graphs of variables
- ◆ Change key variables within graphing window or control panel
- ◆ Imbedded documentation for all elements

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Water Plan Narrative Scenarios Quantified Using Analytica-based Model

- ◆ Urban and Agricultural Demand
 - Based primarily on DWR's spreadsheet models
- ◆ Estimates for each hydrologic region
- ◆ Variable time-step
- ◆ Initial conditions based on 2000 data

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Urban Water Demand Calculated Using Bottom-Up Approach

$$Demand_{HR,Time}^{Urban} = \sum_{u=unit} (DemUnit_{HR,Time}^U \times UseCoef_{HR,Time}^U)$$

◆ Demand Units

- Households
 - ◆ Single- and multi-family
 - ◆ Interior and Exterior
- Commercial Employees
- Industrial Employees
- Institutional Use (per capita)

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Model is Initialized with Year 2000 Data

◆ Residential Sector

- Population
- SF & MF Homes
- Household Size
- Indoor and Outdoor WU

◆ Public / Institutional Sector

- Population
- Public WU

◆ Commercial and Industrial Sectors

- Population
- Commercial & Industrial Employment
- Commercial & Industrial WU

$$UseCoefficient_{HR,2000}^U = \frac{Use_{HR,2000}^U}{DemandUnit_{HR,2000}^U}$$

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Population Changes Drive Housing and Employment

- ◆ SF and MF houses a function of:
 - Population
 - Fraction of population houses
 - Share of SF houses
 - Household Size
- ◆ Com. & Indust. employees a function of:
 - Population
 - Employment rate
 - Commercial Job Fraction
 - ◆ $\text{Commercial Jobs} / (\text{Commercial} + \text{Industrial Jobs})$

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Per unit water demand (water use coefficient)

- ◆ Many factors can influence water use coefficient (WUC)
- ◆ Simplest approach
 - Percentage change in WUC for each sector
 - Easy interpretation
- ◆ In future, disaggregate effects
 - Income, water price, naturally occurring conservation, water use efficiency
 - Permit more permutations for other scenarios

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Irrigation Demand Calculated by Estimating Crop Demand

$$IU = \sum_{HR=1}^R \sum_{crop=1}^C ICA_{crop,HR} \times AW_{crop,HR}$$

- ◆ IU = State-wide irrigation water use
- ◆ ICA = Irrigated crop area
 - Irrigated Land Area + Multi-cropped Area
- ◆ AW = Required applied water per area for each crop

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Required Water for Crops

- ◆ For each crop and HR:

$$AW = ETAW / CF$$

where

ETAW = Evapotranspiration – Effective Precipitation

CF = Consumed Fraction

CF ranges from ~55% for Rice to ~80% for tomatoes

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Irrigation demand change over time

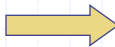
- ◆ IU changes if any of the following change:
 - ILA – change in irrigated land area
 - MA/ILA – change in ratio of multi-cropped area
 - AW – improved varieties of crops, better irrigation methods or technology, change in weather
 - Cropping pattern – currently implemented as change in AW

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Environmental Demand

- ◆ Based on Environmental Defense memo (Dec. 8, 2003)
- ◆ 2000 Unmet demand:

ED Sites	TAF
American	55
Stanislaus	34
ERP #1	0
ERP #2	65
ERP #4	0
Trinity	344
SJR @ Vernalis	96
SJR below Friant	268
Level 4 Refuges	125
Total	987



Hydrologic Region	TAF
NC	344
SF	0
CC	0
SC	0
SR	183
SJ	461
TL	0
NL	0
SL	0
CR	0
Total	987

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